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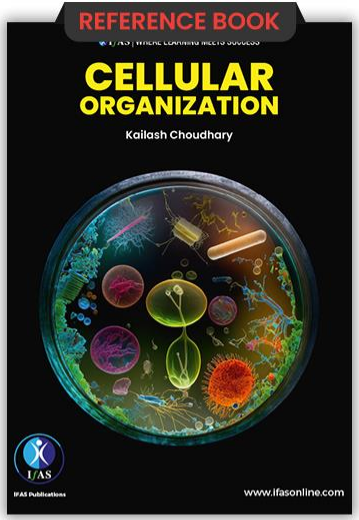
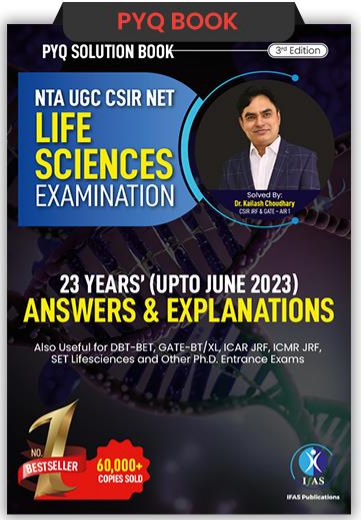
CSIR NET – Life Science

Unit 2: Cellular Organization

L17 | **Microbial Physiology**

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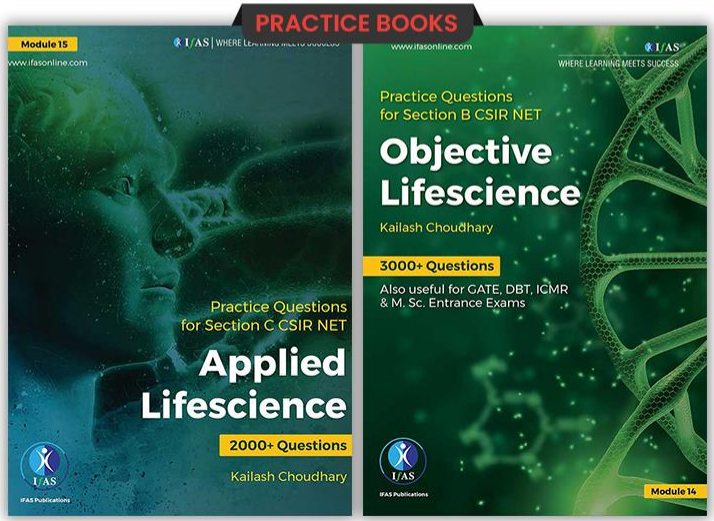

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Points to be covered in this Lecture

- Microbial Physiology
- Microbial growth curve
- Growth kinetics
- Adaption to stress conditions - pH, temp, salt, ROS

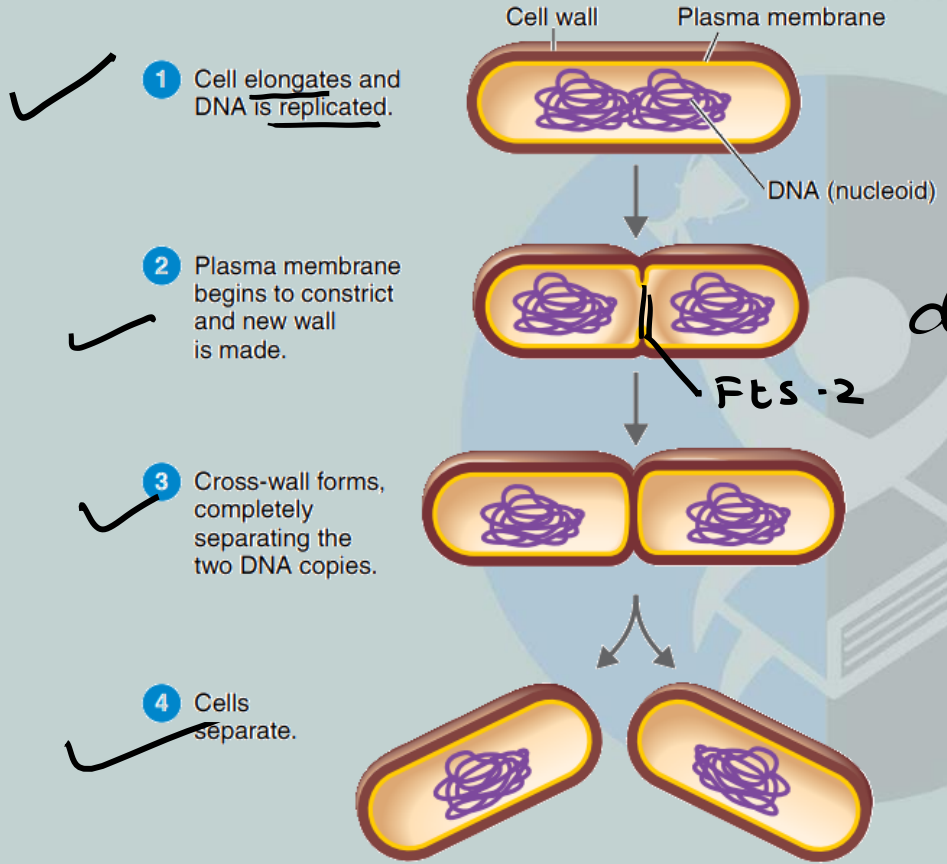
microbial growth

referring to the number of cells, not the size of the cells

microbial growth requirements

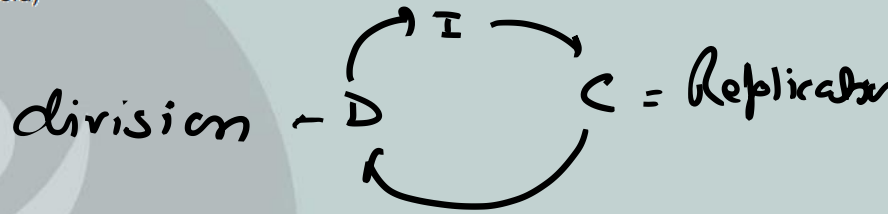
Two main categories:

1. Physical - temperature, pH, and osmotic pressure.
2. Chemical - sources of carbon, nitrogen, sulfur, phosphorus, oxygen, trace elements, and organic growth factors.


Cell wall
Plasma membrane
1 Cell elongates and DNA is replicated.
DNA (nucleoid)
2 Plasma membrane begins to constrict and new wall is made.
Fts -2
3 Cross-wall forms, completely separating the two DNA copies.
4 Cells separate.

(a) A diagram of the sequence of cell division

* Bacterial cell cycle



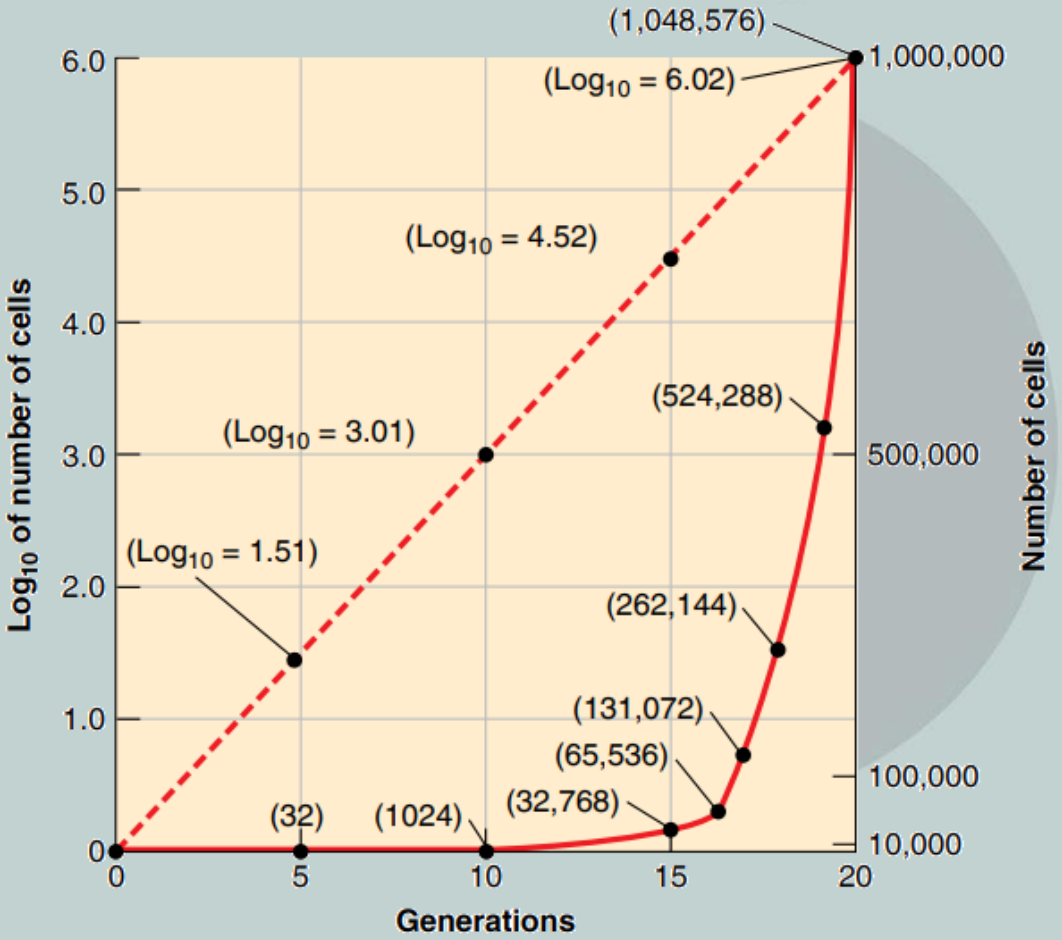
* C & D Phase overlapping

The number of bacteria doubles in each generation.

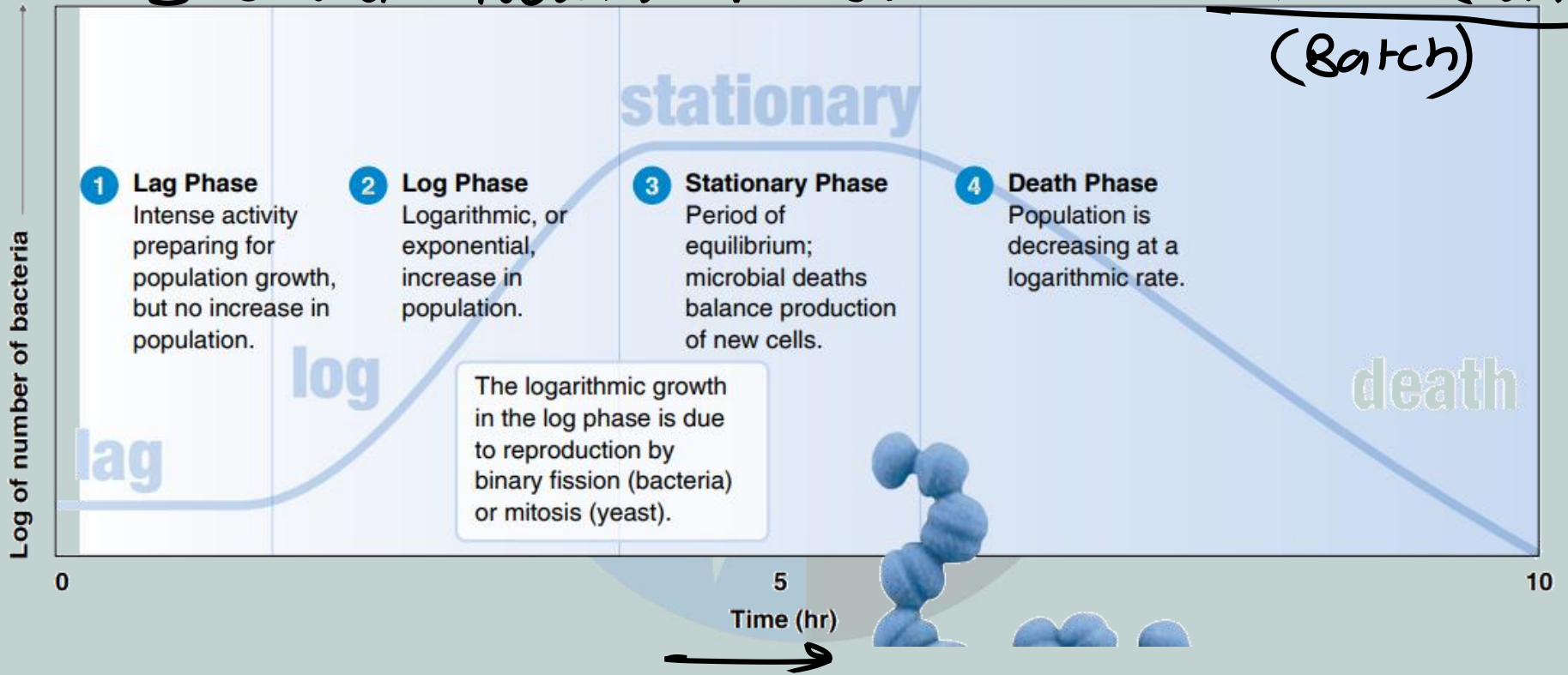
The superscript indicates the generation. n = No. of Generation.

Numbers of Cells	Numbers Expressed as a Power of 2 (3)	Visual Representation of Numbers
1	2^0	●
2	2^1	●●
4	2^2	●●●●
8	2^3	●●●●●●●●
16	2^4	●●●●●●●●●●●●●●●●
32	2^5	●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●

Generation Number	Number of Cells	Log_{10} of Number of Cells
0	$2^0 = 1$	0
5	$2^5 = 32$	1.51
10	$2^{10} = 1{,}024$	3.01
15	$2^{15} = 32{,}768$	4.52
16	$2^{16} = 65{,}536$	4.82
17	$2^{17} = 131{,}072$	5.12
18	$2^{18} = 262{,}144$	5.42
19	$2^{19} = 524{,}288$	5.72
20	$2^{20} = 1{,}048{,}576$	6.02


(1,048,576)
1,000,000
(Log10 = 6.02)
(Log10 = 4.52)
(524,288)
500,000
(Log10 = 3.01)
(Log10 = 1.51)
(262,144)
(131,072)
(65,536)
100,000
(32,768)
(32)
(1024)
10,000
6.0
5.0
4.0
3.0
2.0
1.0
0
0
5
10
15
20
Log10 of number of cells
Number of cells
Generations

Bacterial Growth Pattern in a Culture medium (Batch)


stationary
1 Lag Phase
Intense activity preparing for population growth, but no increase in population.
2 Log Phase
Logarithmic, or exponential, increase in population.
3 Stationary Phase
Period of equilibrium; microbial deaths balance production of new cells.
4 Death Phase
Population is decreasing at a logarithmic rate.
log
lag
death
The logarithmic growth in the log phase is due to reproduction by binary fission (bacteria) or mitosis (yeast).
Log of number of bacteria
0
5
10
Time (hr)

Bacterial Growth Kinetics

$$Nt = No \times 2^n$$

Nt = Total No of population at a time

No = initial No. of n

n = No. of Generation.

Question - 100 bacteria inoculate in a culture after 4 hours

Nt = ?

If generation time is 30 minutes

1 generation = 30 min

in 4 hr = 8 gen.

No = 100

$Nt = No \times 2^n$

$Nt = 100 \times 2^8$

$Nt = 25600$

For Calculation of No. of Generation (n)

$Nt = No \times 2^n$

$$n = \frac{\log Nt - \log No}{\log 2}$$

$n = ?$

if $Nt = 10^8$, $No = 100$ → $n = ?$

if generation time 30min

$$n = \frac{\log 10^8 - \log 10^2}{\log 2}$$

$$= \frac{8 - 2}{.3} = 20 \text{ gen.}$$

$n = 20$ gen.

Mean growth rate K

Number of generation / unit time (per hour)

K = n/t

n = No. of generation
t = time

If n = 20,
t=10

n = 20 gen.
t = 10 hr

=

K = 20/10

2 generation per unit time

K =2 generation per hour

Requirement of Bacterial Growth

(1) Physical Requirement

microbial growth requirements

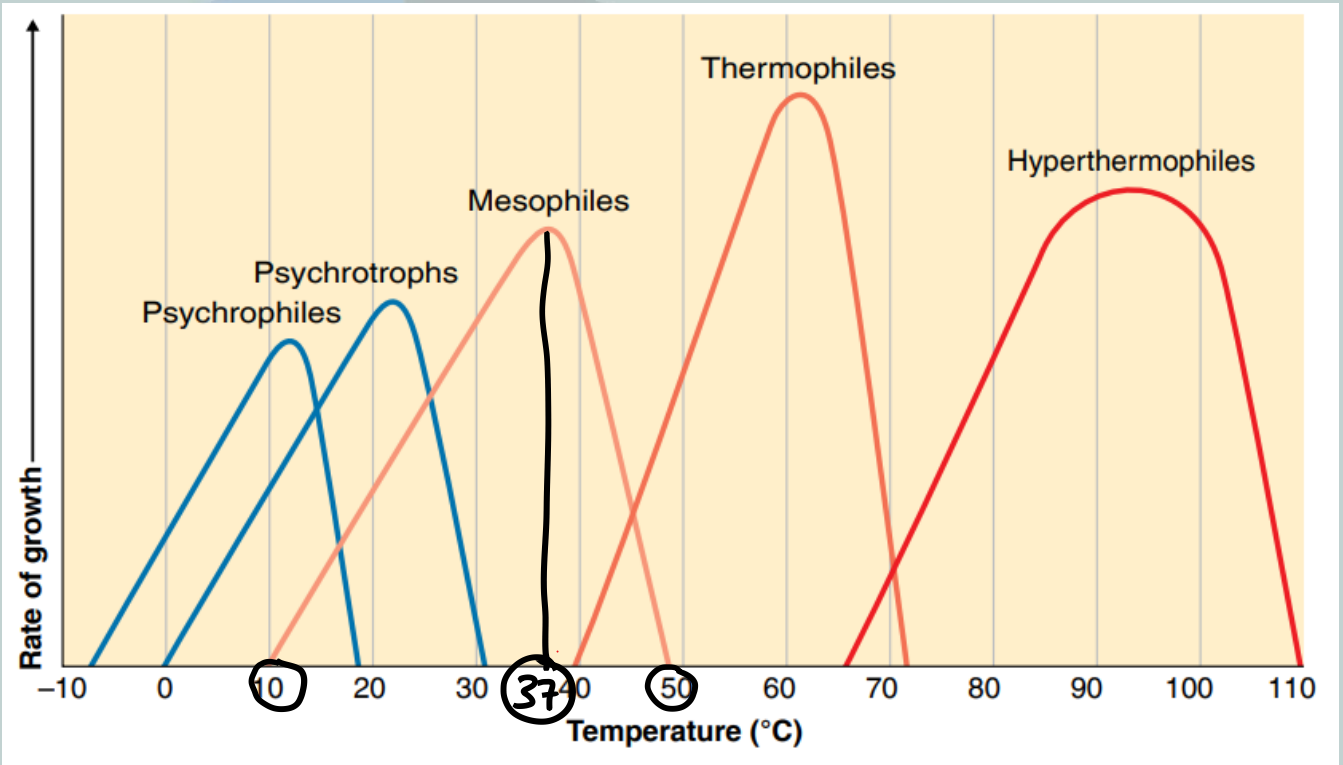
Two main categories:

Physical - temperature, pH, and osmotic pressure.

Chemical - sources of carbon, nitrogen, sulfur, phosphorus, oxygen, trace elements, and organic growth factors.

Physical Requirement

1. **Temperature-**



Temperature

10 to 15 degree centigrade -> psychrophiles	-> *Bacillus psychrophilus*
10 to 20 degree centigrade -> psychrotroph	-> *-Listeria monocytogenes*
15 to 45 degree centigrade -> Mesophiles	-> *E.coli*
55 to 65 degree centigrade -> Thermotroph	-> *Thermus aquaticus*
65 to 75 degree centigrade -> Thermophiles	-> *Pyrococcus*

Psychrophiles -> Contain unsaturated & short chain fatty acyl chain in their plasma membrane (Tm ↓)

Thermophiles

- Saturated & long fatty acyl chain in Plasma membrane

Bacteria can grow in different environment

pH

Acidophiles
Halobacterium pylori

pH 1 to 2

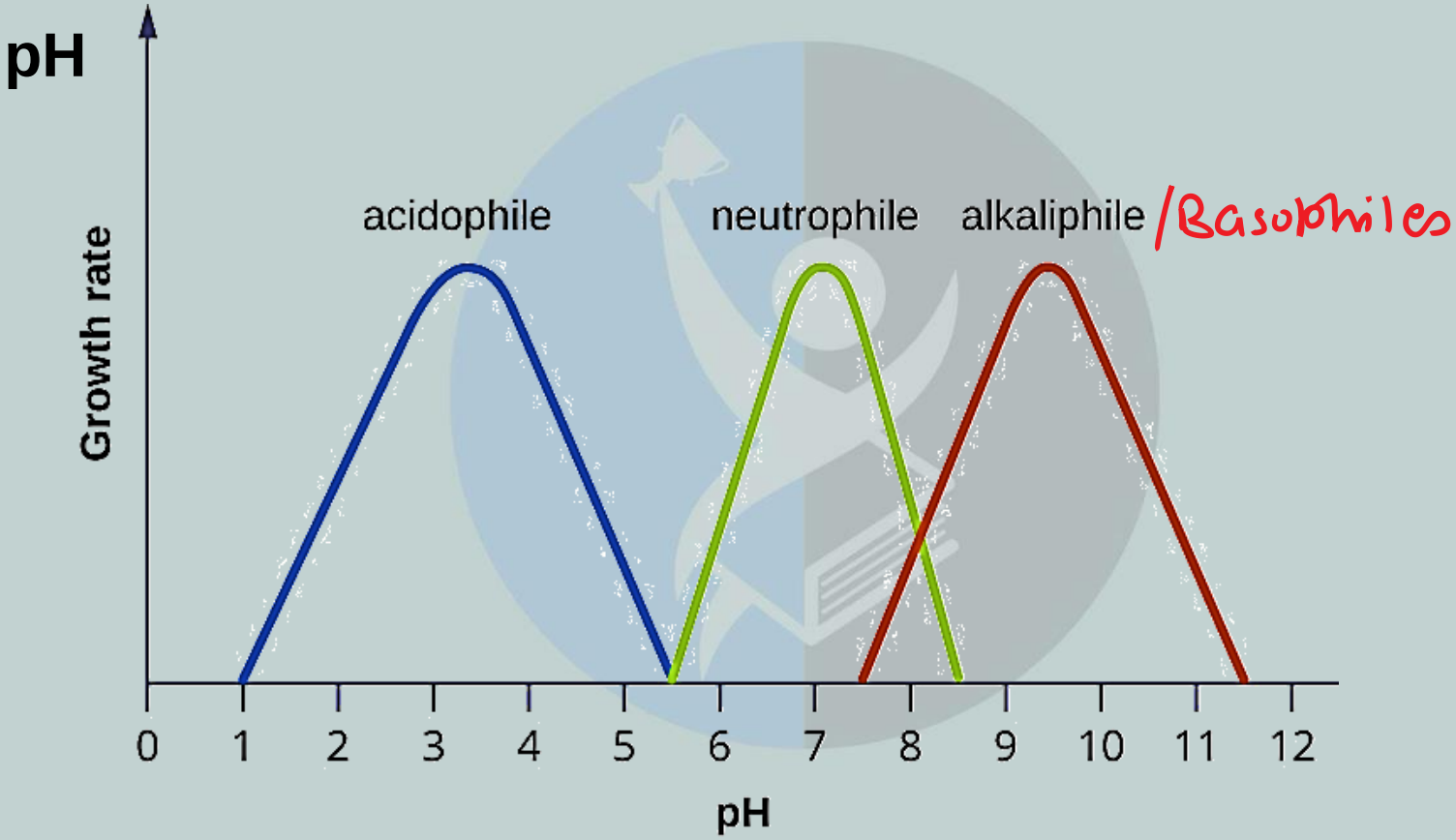
- Cause Stomach ulcer

Neutrophiles
E.coli

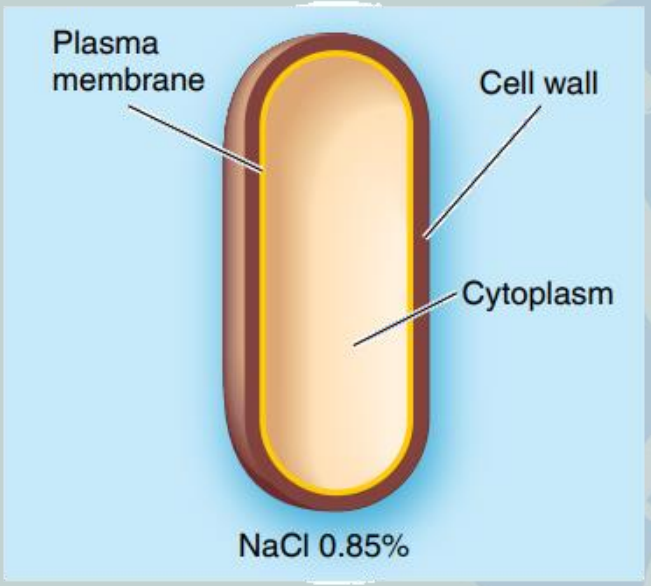
5 to 8 pH

Basophiles → Halophiles
Bacillus species

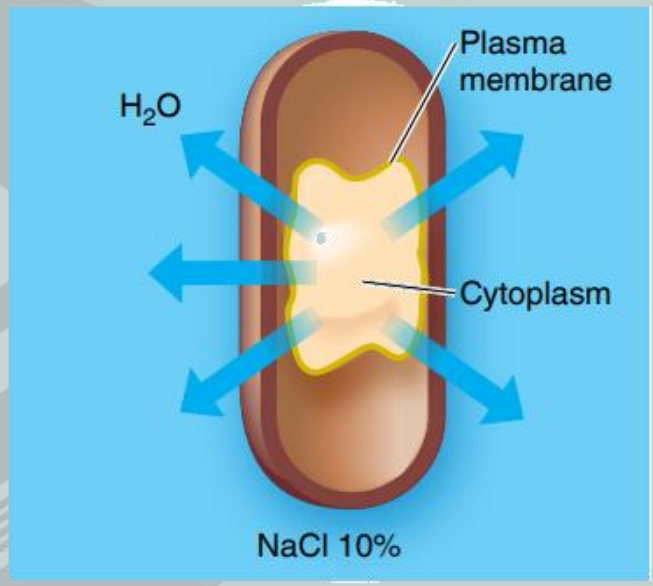
>8 pH → >10


pH
Growth rate
acidophile
neutrophile
alkaliphile
/Basophiles
0
1
2
3
4
5
6
7
8
9
10
11
12
pH

Osmotic Pressure



(a) Cell in isotonic solution. Under these conditions, the solute concentration in the cell is equivalent to a solute concentration of 0.85% sodium chloride (NaCl).



(b) Plasmolyzed cell in hypertonic solution. If the concentration of solutes such as NaCl is higher in the surrounding medium than in the cell (the environment is hypertonic), water tends to leave the cell. Growth of the cell is inhibited.

Extreem Halophiles → lives in Salt water (↑ salinity)

↓

- Adaptation to survive in Extreem Env

TABLE 6.1 The Effect of Oxygen on the Growth of Various Types of Bacteria

	a. Obligate Aerobes	b. Facultative Anaerobes	c. Obligate Anaerobes	d. Aerotolerant Anaerobes	e. Microaerophiles
Effect of Oxygen on Growth	Only aerobic growth; oxygen required.	Both aerobic and anaerobic growth; greater growth in presence of oxygen.	Only anaerobic growth; growth ceases in presence of oxygen.	Only anaerobic growth; but growth continues in presence of oxygen.	Only aerobic growth; oxygen required in low concentration.
Bacterial Growth in Tube of Solid Growth Medium					
Explanation of Growth Patterns	Growth occurs only where high concentrations of oxygen have diffused into the medium.	Growth is best where most oxygen is present, but occurs throughout tube.	Growth occurs only where there is no oxygen.	Growth occurs evenly; oxygen has no effect.	Growth occurs only where a low concentration of oxygen has diffused into medium.
Explanation of Oxygen's Effects	Presence of enzymes catalase and superoxide dismutase (SOD) allows toxic forms of oxygen to be neutralized; can use oxygen.	Presence of enzymes catalase and SOD allows toxic forms of oxygen to be neutralized; can use oxygen.	Lacks enzymes to neutralize harmful forms of oxygen; cannot tolerate oxygen.	Presence of one enzyme, SOD, allows harmful forms of oxygen to be partially neutralized; tolerates oxygen.	Produce lethal amounts of toxic forms of oxygen if exposed to normal atmospheric oxygen.

IMP. Oxygen requirement

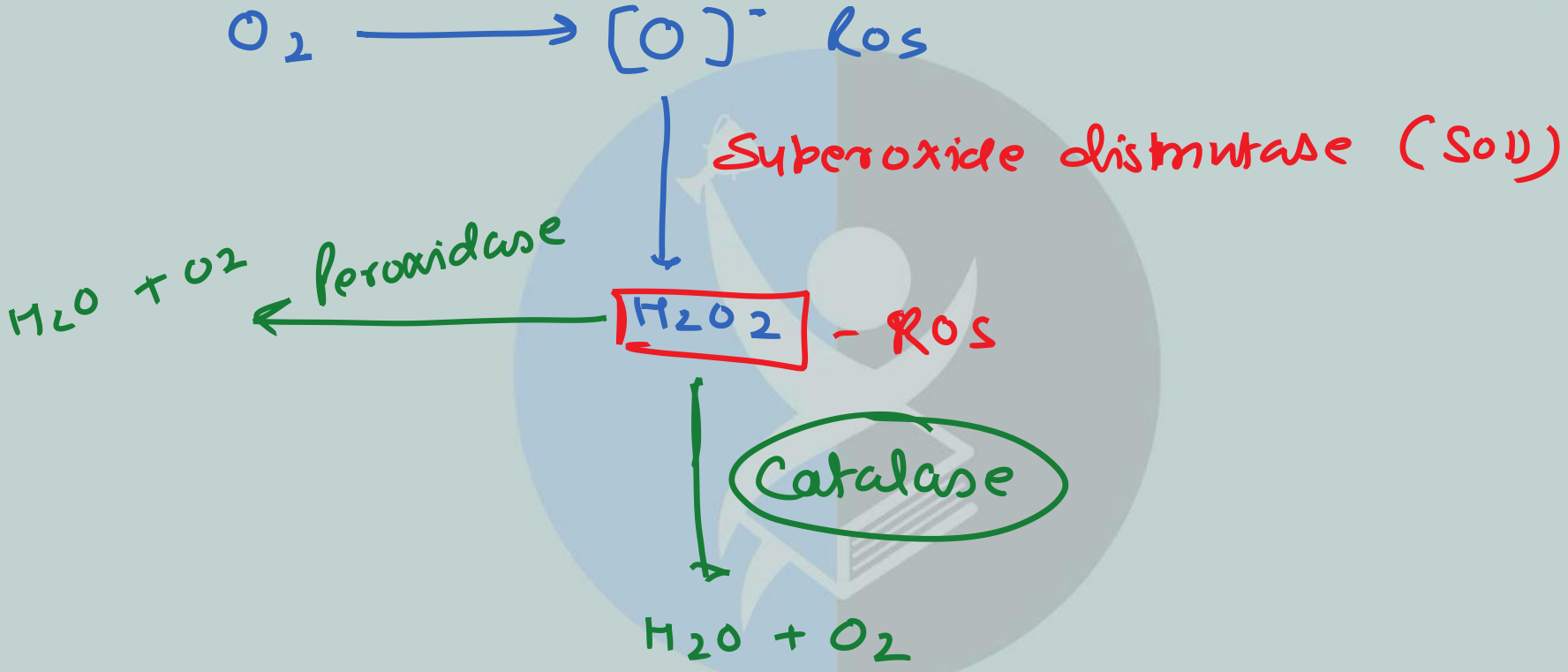
Obligate aerobe - Oxygen required for growth - *Pseudomonas, Mycopacterium*

Facultative anaerobe - Generally aerobic but can survive in anaerobic condition - *E.coli*

Micro aero tolerant	**require low oxygen for survival**	***Campylobacter***
Aero tolerant	survive in both aerobic and anaerobic condition	*Enterobacter*
Obligate anaerobe	cannot survive in presence of oxygen	*Clostridium* and *Methanobacter*

Imp

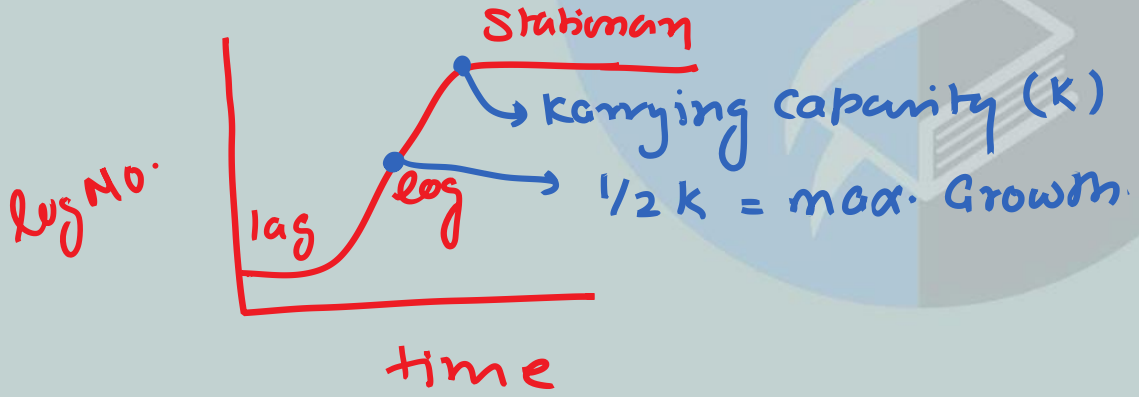
Bacteria	SOD	Catalase	Peroxidase
Obligate aerobe	+	+	-
Facultative anaerobe	+	+	-
Aerotolereant	+	-	+
Obligate aerobe	-	-	-


O2 → [O]⁻ ROS
Superoxide dismutase (SOD)
H2O + O2
Peroxidase
H2O2 - ROS
Catalase
H2O + O2

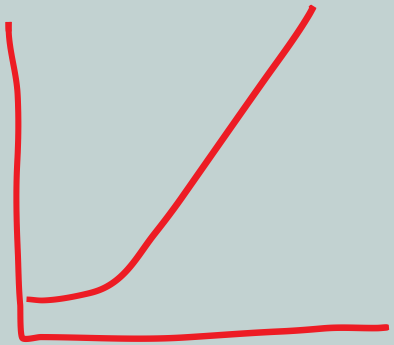
Bacterial Culture

Batch Culture,
Limited Nutrition,

S-Shape Curve,



Continuous Culture
Unlimited Resources
J-Shape Curve



* in Growth Phase (log Phase)

↓

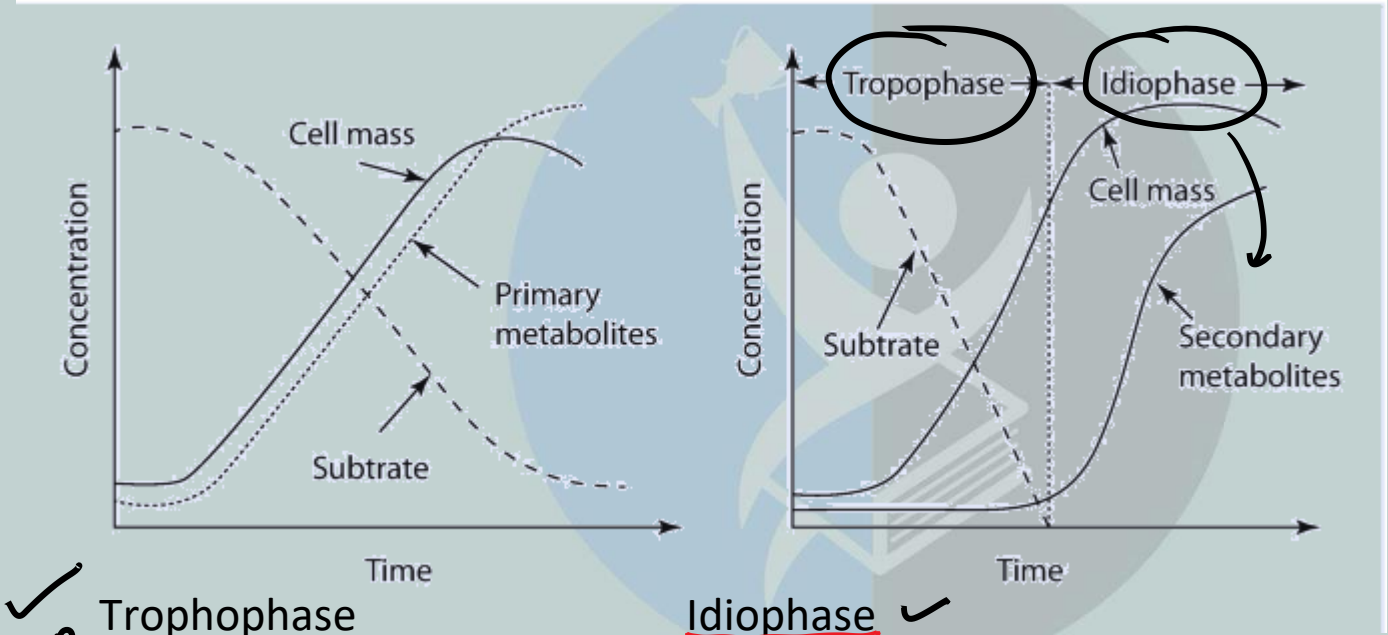
Bacterial cell is very sensitive towards Antibiotic.

least Sensitive in Stationary Phase

TABLE 6.5 Culture Media

Type	Purpose
Chemically Defined	Growth of chemoautotrophs and photoautotrophs; microbiological assays
Complex	Growth of most chemoheterotrophic organisms
Reducing	Growth of obligate anaerobes
Selective	Suppression of unwanted microbes; encouraging desired microbes
Differential	Differentiation of colonies of desired microbes from others
Enrichment	Similar to selective media but designed to increase numbers of desired microbes to detectable levels

- **Production of Metabolites** → Primary and Secondary



✓ Trophophase
1° Metabolites

- Essential for Growth
eg. lactic acid, Ethanol.

Idiophase ✓
2° Metabolites
↳ Not essential for Growth. (commonly)
Eg - Antibiotic

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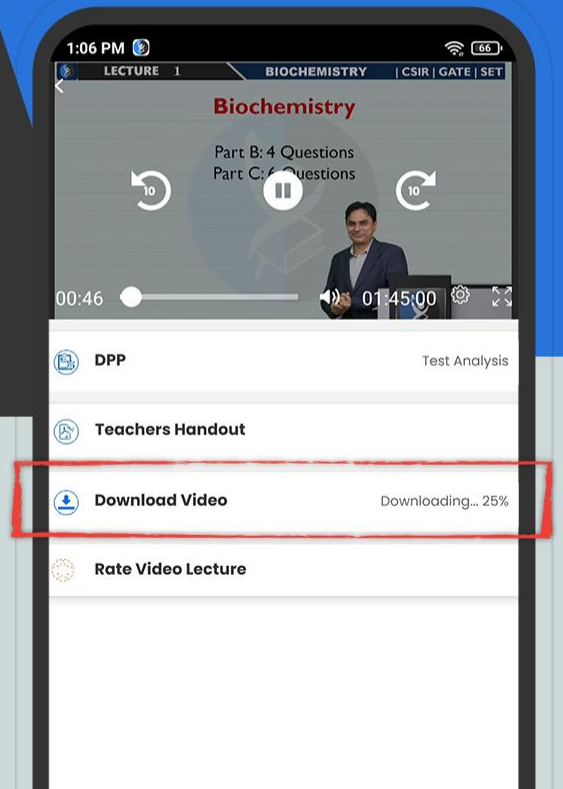

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